MP3314A

6-Channel, 80mA, 50V, Boost WLED Driver with I²C Interface

DESCRIPTION

The MP3314A is a boost converter with 6-channel current sources designed to drive WLED arrays for LCD panels in virtual reality (VR) backlighting applications.

The MP3314A uses peak current mode and pulse-width modulation (PWM) control to maintain boost converter regulation. The integrated 6 channels of the LED current source support a maximum current of 80mA per channel.

The MP3314A provides two PWM input signals (PWM1 and PWM2) to control the brightness of LED channel 1 to channel 3 and LED channel 4 to channel 6, respectively.

The MP3314A employs a standard I²C digital interface to set the LED current, switching frequency (f_{SW}), frequency spread spectrum (FSS), and various protection thresholds.

The MP3314A supports a configurable switching slope and the FSS function to improve EMI performance.

The MP3314A features high efficiency due to low-headroom voltage for LED regulation and the switching MOSFET's small on resistance ($R_{DS(ON)}$).

For system reliability, the MP3314A integrates rich protections, including LED open protection, LED short protection, over-current protection (OCP), over-voltage protection (OVP), and over-temperature protection.

The MP3314A is available in a WLCSP-20 (1.7mmx2.45mm) package.

FEATURES

- 6 Channels with Maximum 80mA/Channel
- Integrated 50V, 130mΩ, On Resistance ($R_{DS(ON)}$) Low-Side MOSFET (LS-FET)
- 3V to 30V Input Voltage (V_{IN}) Range
- Up to 43V of Output Voltage (V_{OUT})
- 187.5mV LED Regulation Voltage at 20mA
- 2% I_{LED} Accuracy, <3% LED Current (I_{LED}) Matching at 20mA
- Selectable Switching Frequency (f_{SW}): 312kHz, 625kHz, or 1250kHz
- I²C Brightness Control
- Manual Mode and Direct Pulse-Width Modulation (PWM) Dimming
- PWM1 and PWM2 Input Signals to Control Channel 1 to Channel 3 and Channel 4 to Channel 6, Respectively
- Configurable Switching Slope and Frequency Spread Spectrum (FSS) Function to Improve EMI
- One-Time Programmable (OTP) Memory for Customizable Default Register Values
- LED Open/Short Protection
- Over-Temperature Protection
- Over-Current Protection (OCP), Inductor, or Diode Short Protection
- Available in a WLCSP-20 (1.7mmx2.45mm) Package

APPLICATIONS

- Virtual Reality (VR) Displays
- LCD Panel Backlighting

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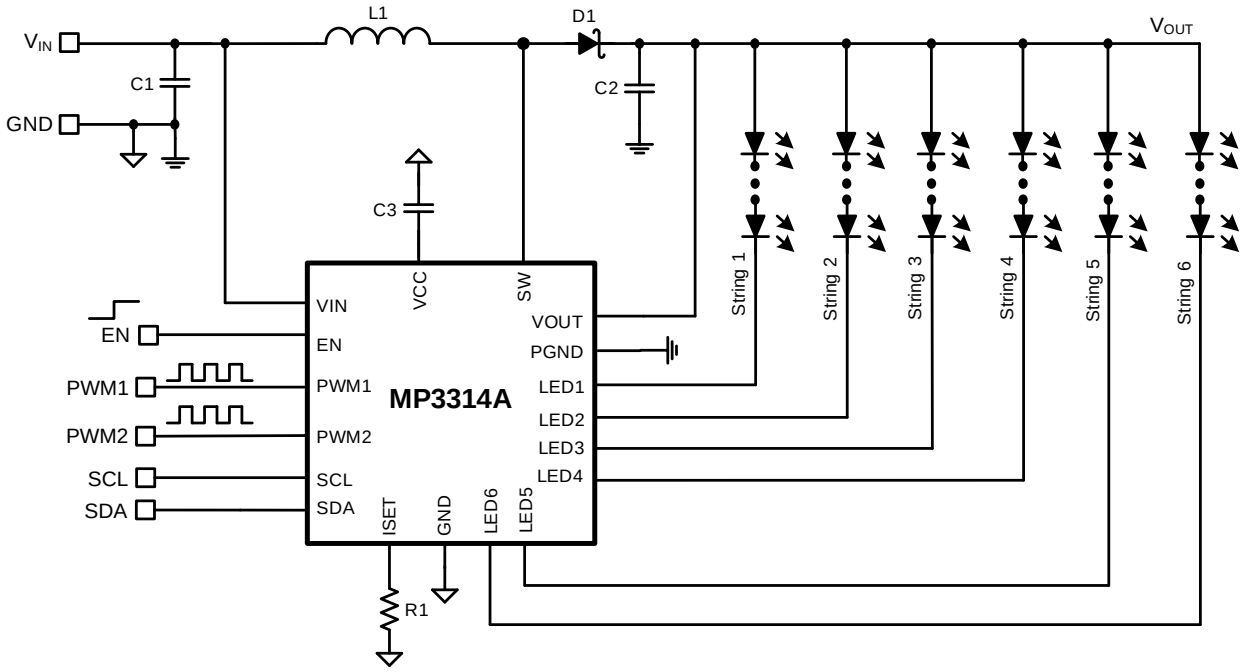
TYPICAL APPLICATION



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ORDERING INFORMATION

Part Number	Package	Top Marking	MSL Rating
MP3314AGC*	WLCSP-20 (1.7mmx2.45mm)	*See Below*	1

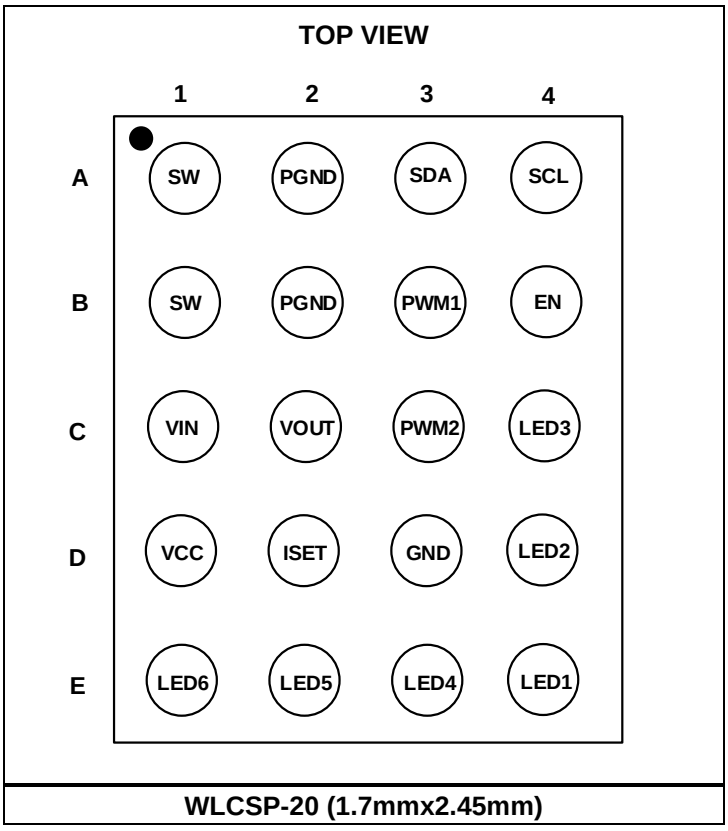
* For Tape & Reel, add suffix -Z (e.g. MP3314AGC-Z).

TOP MARKING

PEY
LLL

PE: Product code
Y: Year code
LLL: Lot number

PACKAGE REFERENCE



WLCSP-20 (1.7mmx2.45mm)

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PIN FUNCTIONS

Pin #	Name	Description
A1, B1	SW	**Drain for the internal low-side MOSFET (LS-FET) switch.**
A2, B2	PGND	**Power ground.**
A3	SDA	**I²C interface data input/output.**
A4	SCL	**I²C interface clock input.**
B4	EN	**IC enable.** Pull the EN pin high to enable the IC; pull EN low to force the IC to enter shutdown mode. A nearby RC filter is required for this pin.
B3	PWM1	**External pulse-width modulation (PWM) signal input 1.** Apply a 50Hz to 5kHz PWM signal on the PWM1 pin for the brightness control of channel 1 to channel 3.
D3	GND	**Chip ground.**
E4	LED1	**LED string 1 current input.** Connect LED string 1's cathode to the LED1 pin.
D4	LED2	**LED string 2 current input.** Connect LED string 2's cathode to the LED2 pin.
C4	LED3	**LED string 3 current input.** Connect LED string 3's cathode to the LED3 pin.
E3	LED4	**LED string 4 current input.** Connect LED string 4's cathode to the LED4 pin.
E2	LED5	**LED string 5 current input.** Connect LED string 5's cathode to the LED5 pin.
E1	LED6	**LED string 6 current input.** Connect LED string 6's cathode to the LED6 pin.
D1	VCC	**5V low-dropout (LDO) output.** The VCC pin provides power for the internal logic and gate driver. Place a ceramic capacitor as close to VCC as possible to reduce noise.
C2	VOUT	**Output voltage detection.** Connect the power diode's cathode to the VOUT pin.
C3	PWM2	**External PWM signal input 2.** Apply a 50Hz to 5kHz PWM signal on the PWM2 pin for the brightness control of channel 4 to channel 6.
C1	VIN	**Power supply input.** A nearby bypass capacitor is required for the VIN pin.
D2	ISET	**LED current setting.** Connect a current-setting resistor between the ISET and GND pins to configure the current in each LED string.

ABSOLUTE MAXIMUM RATINGS (1)

V_{SW}, V_{LEDx}, V_{OUT} ..... -0.3V to +50V
V_{IN}..... -0.3V to +32V
All other pins..... -0.3V to +5.3V
Junction temperature (T_J) ..... 150°C
Lead temperature ..... 260°C
Storage temperature..... -65°C to +150°C
Continuous power dissipation (T_A = 25°C) (2)
WLCSP-20 (1.7mmx2.45mm) 2.5W

ESD Ratings

Human body model (HBM) .....±2kV
Charged-device model (CDM) .....
.....+1.5kV/-1.25kV

Recommended Operating Conditions (3)

Supply voltage (V_{IN}) ..... 3V to 30V
Operating junction temp (T_J) .... -40°C to +125°C

Thermal Resistance (4) θ_{JA} θ_{JC}

WLCSP-20 (1.7mmx2.45mm).....
.....50....0.5.....°C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature, T_J (MAX), the junction-to-ambient thermal resistance, θ_{JA}, and the ambient temperature, T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX) - T_A) / θ_{JA}. Exceeding the maximum allowable power dissipation produces an excessive die temperature, causing the regulator to go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on a JESD51-7, 4-layer PCB.

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ELECTRICAL CHARACTERISTICS

V_{IN} = 7.6V, V_{EN} = 2V, T_J = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Input Voltage Supply						
Operating input voltage	V_{IN}		3		30	V
Supply current	$I_{STANDBY}$	LDO enabled, boost disabled, -30°C to +85°C		1.6	1.8	mA
	I_{NORMAL}	LDO enabled, boost enabled, no load		3	3.4	mA
Shutdown supply current	I_{ST}	V_{EN} = 0V			1	µA
Input under-voltage lockout (UVLO) threshold	V_{IN_UVLO}	Rising edge	2.3	2.5	2.7	V
Input UVLO hysteresis				125		mV
Low-dropout (LDO) output voltage	V_{CC}	V_{EN} = 2V, 6V < V_{IN} < 30V, 0mA < I_{VCC} < 10mA	4.5	5	5.5	V
EN on threshold	V_{EN_ON}	V_{EN} rising	1.2			V
EN off threshold	V_{EN_OFF}	V_{EN} falling			0.4	V
EN pull-down resistor	R_{EN}			1000		kΩ
Step-Up Converter						
Low-side MOSFET (LS-FET) on resistance	$R_{DS(ON)_LS}$	V_{IN} = 3.6V		130		mΩ
SW leakage current	I_{SW_LK}	V_{SW} = 50V			1	µA
Switching frequency	f_{SW}	FSW (0Ah, [bits[5:4]) = 10b	1200	1250	1300	kHz
		FSW (0Ah, [bits[5:4]) = 01b	610	645	680	kHz
Maximum duty cycle	D_{MAX}	FSW (0Ah, [bits[5:4]) = 10b	89			%
		FSW (0Ah, [bits[5:4]) = 01b	90			%
Cycle-by-cycle current limit	I_{SW_LIMIT}	ILIM (02h, bits[5:3]) = 000b	0.35	0.45	0.55	A
		ILIM (02h, bits[5:3]) = 101b		1.2		A
Latch off current limit	I_{CL}	ILIM (02h, bits[5:3]) = 101b	2.3	2.9	3.5	A
Minimum turn on time	t_{MIN_ON}			90		ns
Dimming						
Pulse-width modulation (PWM) input high threshold	V_{PWM_HI}	V_{PWM} rising	1.2			V
PWM input low threshold	V_{PWM_LO}	V_{PWM} falling			0.4	V
PWM pull-down resistor	R_{PWM}			1000		kΩ
Minimum on/off time	$t_{MIN_ON/OFF}$			1		µs
PWM1 input low time for standby mode	$t_{STANDBY}$		50	58	66	ms

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ELECTRICAL CHARACTERISTICS *(continued)*

V_{IN} = 7.6V, V_{EN} = 2V, T_J = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
LED Current Regulation						
Current matching (6)		V_{LEDx} = 187.5mV, I_{LED} = 20mA			3	%
Full-scale current		ILED, bits[11:0] = FFFh, IMAX (07h, bits[6:4]) = 111b, R_{ISET} = 40kΩ	49	50.5	52	mA
		ILED, bits[11:0] = FFFh, IMAX (07h, bits[6:4]) = 011b, R_{ISET} = 40kΩ	19.6	20	20.4	mA
Maximum LED current	I_{LED_MAX}	R_{ISET} = 25kΩ, IMAX (07h, bits[6:4]) = 111b		80		mA
LEDx leakage current	I_{LED_LKG}	V_{OUT} = 50V			1	µA
Protection						
Over-voltage protection (OVP) threshold	V_{OVP}	Rising edge, OVP (04h, bits[5:3]) = 111b		43		V
		Rising edge, OVP (04h, bits[5:3]) = 010b		21		V
OVP UVLO threshold	V_{OVP_UV}	The step-up converter fails		1		V
LEDx over-voltage (OV) threshold	V_{LEDx_OV}	LEDS (0Bh, bits[3:2]) = 01b		5		V
LEDx OV fault timer				1.8		ms
LEDx UVLO threshold	V_{LEDx_UV}			80		mV
Thermal shutdown threshold	T_{ST}	Rising edge (5)		150		°C
		Hysteresis (5)		20		°C
I²C Interface						
Input logic low	V_{IL}				0.54	V
Input logic high	V_{IH}		1.5			V
Output logic low (5)	V_{OL}	I_{LOAD} = 3mA			0.4	V
SCL clock frequency (5)	f_{SCL}		10		1000	kHz
Bus free time (5)	t_{BUF}	Between the stop and start command	0.5			µs
Holding time after repeated start command (5)	t_{HD_STA}	After this period, the first clock is generated	0.26			µs
Repeated start command set-up time (5)	t_{SU_STA}		0.26			µs
Stop condition set-up time (5)	t_{SU_STO}		0.26			µs
Data hold time (5)	t_{HD_DAT}		0			ns
Data set-up time (5)	t_{SU_DAT}		50			ns
Clock low timeout (5)	$t_{TIMEOUT}$		25		35	ms
Clock low time (5)	t_{LOW}		0.5			µs
Clock high time (5)	t_{HIGH}		0.26		50	µs
Clock/data falling time (5)	t_F				120	ns
Clock/data rising time (5)	t_R				120	ns

Notes:

5) Not tested in production. Guaranteed by characterization.
6) Matching is defined as the difference between the maximum current and minimum current, divided by 2 times the average current.

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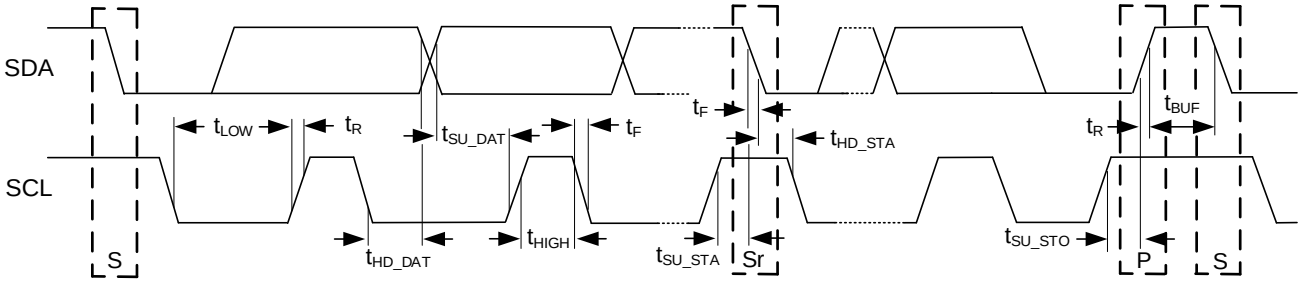
TIMING DIAGRAM



S = Start Command
Sr = Repeated Start Command
P = Stop Command

Figure 1: I²C-Compatible Interface Timing Diagram

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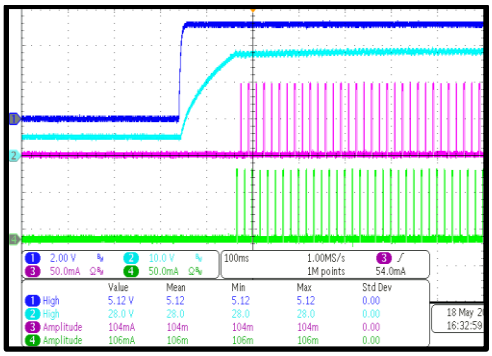
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN_BOOST} = 2.5V, V_{IN_IC} = EN = 5V, f_{PWM} = 60Hz, duty = 13%, LED = 4P8S, I_{SET} = 45mA/Ch, CL = 0.75A, f_{SW} = 625kHz, L = 3.3µH, T_A = 25°C, unless otherwise noted.

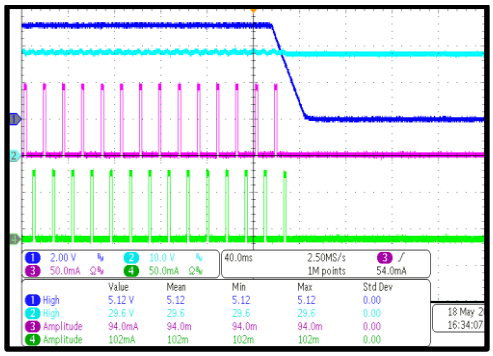
V_{IN_IC} Start-Up

CH1: V_{IN_IC}
CH2: V_{OUT}
CH3: $I_{CH1 + CH2}$
CH4: $I_{CH5 + CH6}$



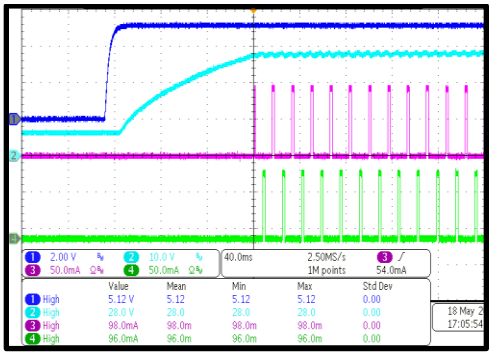
V_{IN_IC} Shutdown

CH1: V_{IN_IC}
CH2: V_{OUT}
CH3: $I_{CH1 + CH2}$
CH4: $I_{CH5 + CH6}$



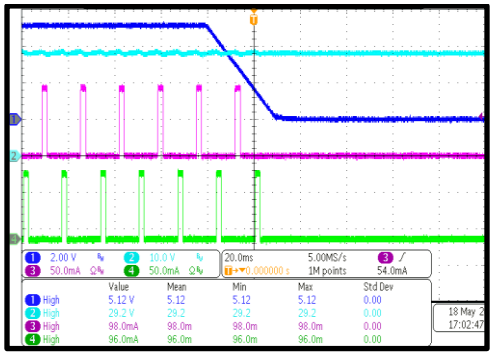
Start-Up through EN

CH1: EN
CH2: V_{OUT}
CH3: $I_{CH1 + CH2}$
CH4: $I_{CH5 + CH6}$



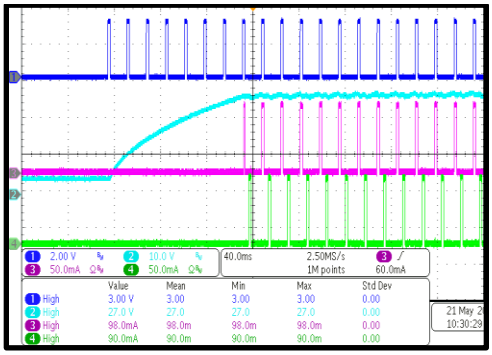
Shutdown through EN

CH1: EN
CH2: V_{OUT}
CH3: $I_{CH1 + CH2}$
CH4: $I_{CH5 + CH6}$



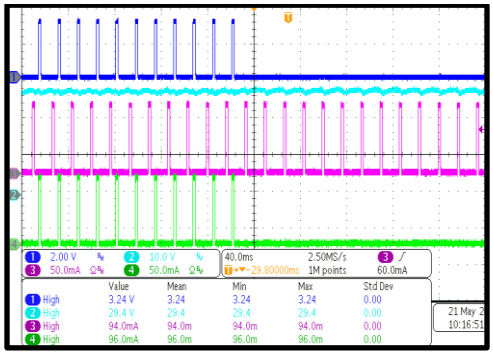
Start-Up through PWM2, then Start-Up through PWM1

CH1: PWM1
CH3: $I_{CH1 + CH2}$
CH2: V_{OUT}
CH4: $I_{CH5 + CH6}$



Shutdown through PWM2 First

CH1: PWM2
CH3: $I_{CH1 + CH2}$
CH2: V_{OUT}
CH4: $I_{CH5 + CH6}$



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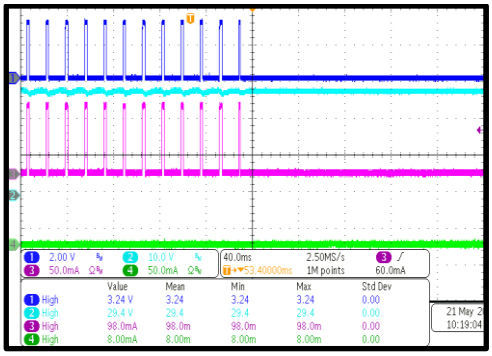
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN_BOOST} = 2.5V, V_{IN_IC} = EN = 5V, f_{PWM} = 60Hz, duty = 13%, LED = 4P8S, I_{SET} = 45mA/Ch, CL = 0.75A, f_{SW} = 625kHz, L = 3.3µH, T_A = 25°C, unless otherwise noted.

Shutdown through PWM1 Second

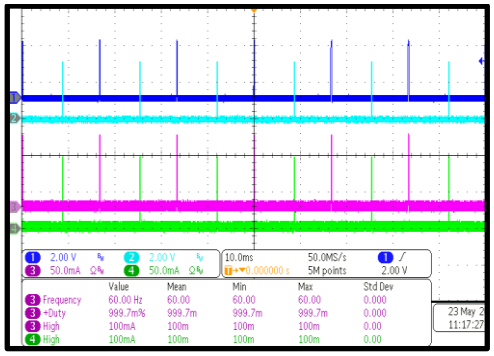
CH1: PWM1
CH3: $I_{CH1 + CH2}$
CH2: V_{OUT}
CH4: $I_{CH5 + CH6}$



Direct PWM Dimming

Duty = 1%

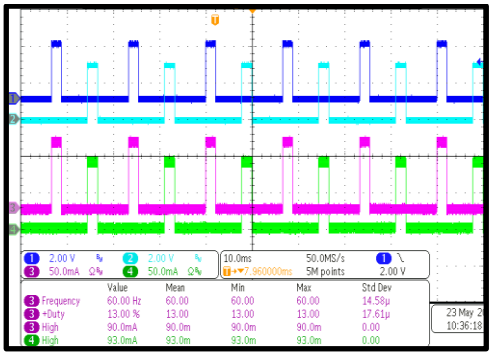
CH1: PWM1
CH2: PWM2
CH3: $I_{CH1 + CH2}$
CH4: $I_{CH5 + CH6}$



Direct PWM Dimming

Duty = 13%

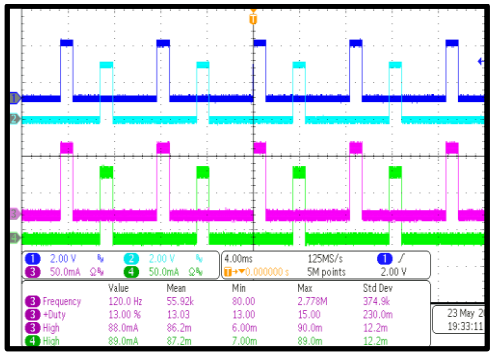
CH1: PWM1
CH2: PWM2
CH3: $I_{CH1 + CH2}$
CH4: $I_{CH5 + CH6}$



Direct PWM Dimming

f_{PWM} = 120Hz

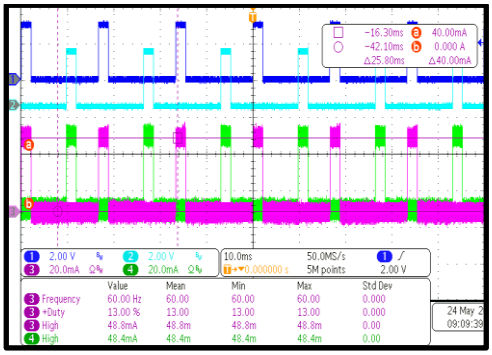
CH1: PWM1
CH2: PWM2
CH3: $I_{CH1 + CH2}$
CH4: $I_{CH5 + CH6}$



Direct PWM Dimming

I_{LED} = 20mA

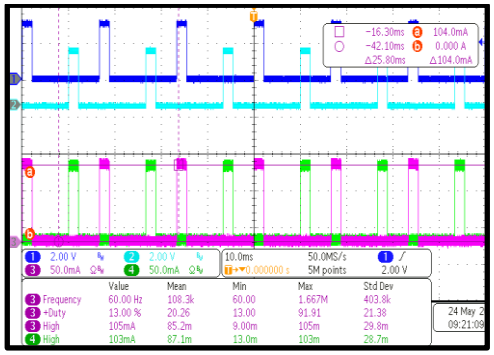
CH1: PWM1
CH2: PWM2
CH3: $I_{CH1 + CH2}$
CH4: $I_{CH5 + CH6}$



Direct PWM Dimming

I_{LED} = 50mA

CH1: PWM1
CH2: PWM2
CH3: $I_{CH1 + CH2}$
CH4: $I_{CH5 + CH6}$



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TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

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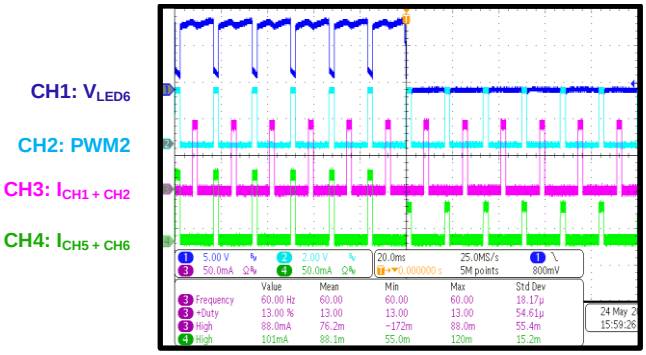
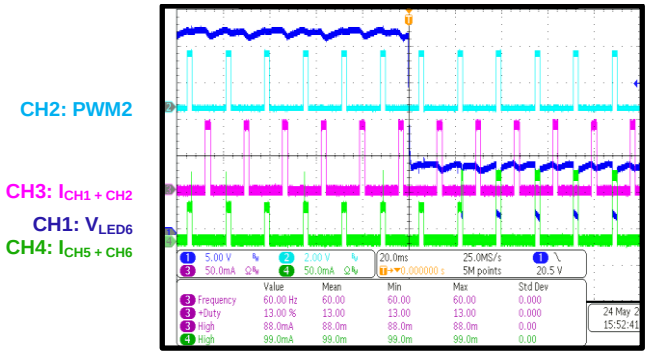
LED Open Protection

Open LED string 6



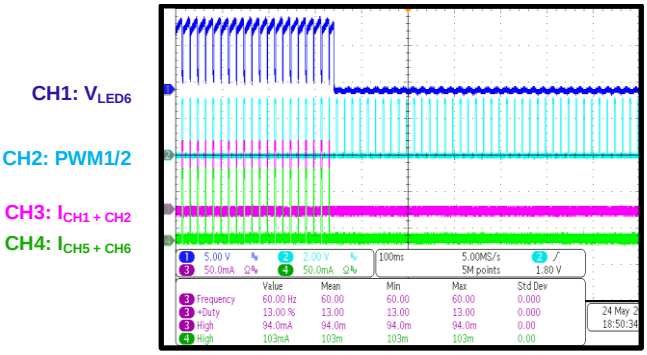
LED Short Protection

Short LED string 6



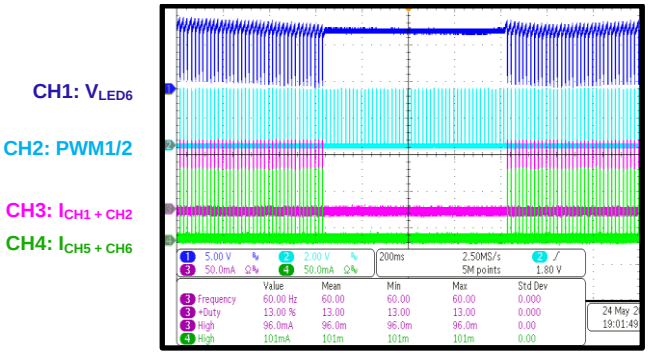
Latch-Off Current-Limit Protection

Short diode during normal operation



Over-Temperature Protection

Heat the IC manually, then recover



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FUNCTIONAL BLOCK DIAGRAM

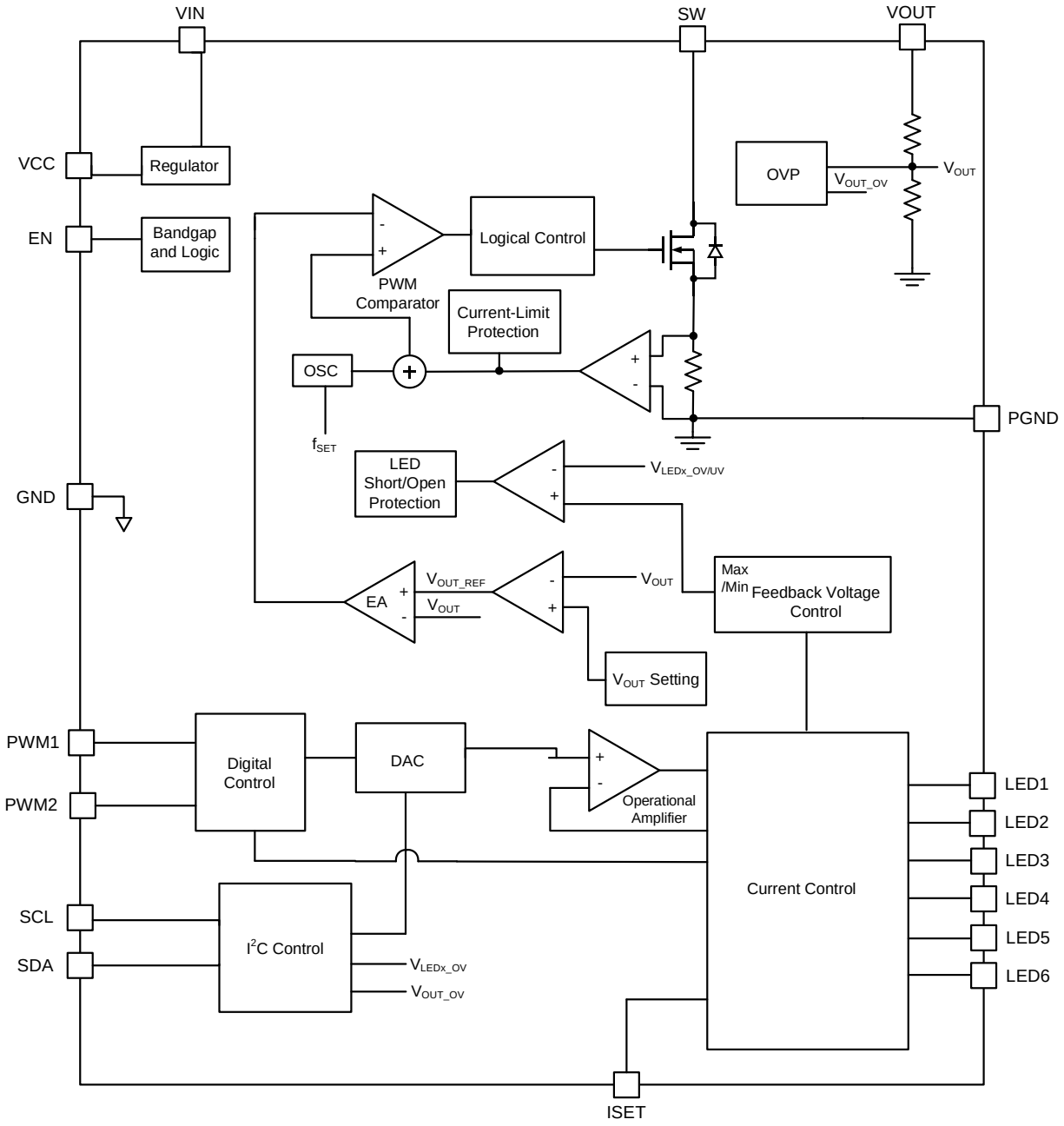

Figure 2: Functional Block Diagram

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OPERATION

The MP3314A is a fixed-frequency, peak current mode, step-up converter with up to 6 channels of regulated current sources to drive an array of white LEDs. The device integrates a low-side MOSFET (LS-FET) with a 50V rating, which supports a maximum 43V output voltage (V_{OUT}).

Internal Regulator

The MP3314A includes an internal linear regulator (VCC). When the input voltage (V_{IN}) exceeds 6V and the EN pin is high, this regulator outputs a 5V power supply for the internal MOSFET gate driver and internal control circuitry.

When the boost input voltage (V_{IN_BOOST}) is below 3.5V, it is recommended to use an external 5V power supply to the VIN pin, which helps improve system efficiency.

Internal Clock

The MP3314A provides a fixed 20MHz clock for the internal digital logic.

Switching Frequency of the Boost Converter

The boost converter's switching frequency (f_{SW}) can be set via FSW (0Ah, bits[5:4]). f_{SW} can be set to 312kHz, 625kHz, and 1250kHz.

System Start-Up

When enabled, the MP3314A checks the topology connection. The IC monitors V_{OUT} to determine if the output is shorted to GND. If V_{OUT} is below 1V, the IC is disabled. Then the MP3314A continues to check other safety limits, such as LED open protection and over-voltage protection (OVP). If all protection tests pass, the IC begins boosting the step-up converter with an internal soft start (SS).

The MP3314A can start up properly regardless of the start-up sequence of VIN, PWM1, PWM2, and EN. Figure 3 shows the recommended start-up sequence to achieve a quick response.

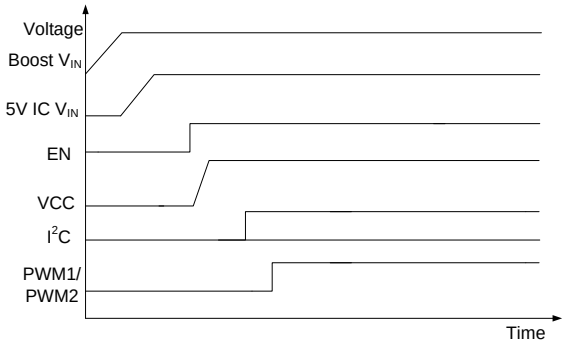

Figure 3: Recommended Start-Up Sequence

The start-up sequence occurs in the following order:

1. Boost VIN start-up
2. IC VIN start-up
3. EN start-up, then wait for 2ms
4. Send the I²C data
5. Apply the external PWM1 and PWM2 signal. When PWM1 or PWM2 is disabled, the corresponding channels remain off.

If SBY_PWM = 1b and PWM1 remains low for longer than 58ms, then the IC enters standby mode, and all blocks are disabled, except for the I²C.

Step-Up Converter

The MP3314A uses peak current mode control to regulate V_{OUT}. At the beginning of each switching cycle, the internal clock turns on the low-side N-channel MOSFET. In normal operation, the minimum turn-on time is about 90ns. A stabilizing ramp added to the current-sense amplifier's output prevents subharmonic oscillations for duty cycles exceeding 50%. This result is fed into the pulse-width modulation (PWM) comparator. When the summed voltage reaches V_{OUT} of the error amplifier (EA), the LS-FET turns off.

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Output Voltage Regulation in Manual Mode

For V_{OUT} regulation, the MP3314A only supports manual control mode, and the boost output voltage (V_{OUT_BOOST}) can be set directly via VO (0Eh, bits[7:0]).

Pulse-Skip Mode (PSM)

During light-load operation, especially when $V_{OUT} \approx V_{IN}$, the converter runs in pulse-skip mode (PSM), where the MOSFET turns on for a minimum on time. In this mode, the device keeps the power switch off for several switching cycles to prevent V_{OUT} from exceeding the regulated voltage. When the device stops switching, the output capacitor (C_{OUT}) discharges to power the LED string. The device begins switching until V_{OUT} must be boosted again.

Direct Pulse-Width Modulation (PWM) Dimming

The MP3314A only supports direct PWM dimming mode. The frequency and duty of the LED current (I_{LED}) directly follow the external PWM input signal. The I_{LED} amplitude is determined by IMAX (07h, bits[6:4]) and ILED, bits[11:0], which is the combination of ILED11:8 (07h, bits[3:0]) and ILED7:0 (06h, bits[7:0]), as well as the ISET resistor (R_{ISET}) if it is enabled. PWM1 controls the channel 1 to channel 3 current, and PWM2 controls the channel 4 to channel 6 current, respectively.

Frequency Spread Spectrum (FSS)

The MP3314A uses f_{SW} jitter to spread the f_{SW} spectrum, which reduces the spectrum spike around f_{SW} and its harmonic frequencies.

The frequency spread spectrum (FSS) range is selected by FSPR (0Bh, bit[4]), where:

- FSPR = 0b (default). The jitter range is 1/10 of f_{SW}.
- FSPR = 1b. The jitter range is 1/16 of f_{SW}.

The modulation frequency is selected by FSPMF (0Bh, bits[6:5]).

- FSPMF = 00b. The modulation frequency is 1/100 of f_{SW}.
- FSPMF = 01b. The modulation frequency is 1/150 of f_{SW}.
- FSPMF = 10b. The modulation frequency is 1/200 of f_{SW}.
- FSPMF = 11b (default). The function is disabled.

Switching Slew Rate Setting

The MP3314A provides three types of driving capability for the internal MOSFET to improve the EMI performance. Set SRSW (0Ah, bits[7:6]) to configure the driving capability. EMI performance improves as driving capability decreases. However, there is a tradeoff between slow switching speed and efficiency.

Unused LED Channel Setting

The MP3314A can detect an unused LED string automatically and remove it from the voltage control loop during start-up by setting the corresponding CHEN bits (or CHENx where x = 0, 1, 2, 3, 4, or 5) to 0.

Protection

The MP3314A includes LED open protection, LED short protection, LEDx short to GND protection, over-current protection (OCP), and thermal protection. Once any of these protections are triggered, the corresponding fault bit is set to 1.

Input Under-Voltage Lockout (UVLO) Protection

Input UVLO protection can be enabled or disabled via UVLO_EN (08h, bit[5]). When UVLO_EN = 0b, this function is disabled, and the status of FT_UVLO (1Fh, bit[6]) is disregarded. If UVLO_EN = 1b and V_{IN} is below the UVLO threshold, then the IC shuts down, and the I²C becomes inactive. If V_{IN} and EN remain valid, once V_{IN} recovers to exceed the UVLO threshold, then the IC recovers and the UVLO fault can be read to indicate a V_{IN} UVLO condition.

LED Open Protection

LED open protection is achieved by detecting the voltage of the LED1 to LED6 pins.

In manual mode, if a LEDx pin voltage is below the LEDx UVLO threshold when dimming is on and the fault condition lasts for about 24ms, then LED open protection is triggered.

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LED Short Protection

The MP3314A monitors the LEDx pin voltages to determine if a LED short fault has occurred. If one or more LED strings are shorted, then the respective LEDx pins tolerate high voltage stress. If a LEDx pin voltage exceeds the protection threshold (set via LEDS (0Bh, bits[3:2])), then an internal counter starts. If this fault condition lasts for 1.8ms, the fault LED string is marked off and disabled. Once a string is marked off, it is disconnected from the V_{OUT} loop. Both LED open and short protection are recoverable.

LED short protection works only when a minimum of one LEDx voltage is regulated to the optimized voltage.

Cycle-by-Cycle Current Limit

To prevent the external components from exceeding the current stress rating, the IC integrates cycle-by-cycle current-limit protection. The limit can be selected by ILIM (02h, bits[5:3]). When the current exceeds the current limit, the LS-FET turns off immediately until the next clock cycle begins.

Latch-Off Current-Limit Protection

To avoid device damage caused by a large current (such as an inductor or diode short), the MP3314A uses a latch-off current-limit protection. When the current flowing through the LS-FET reaches the latch-off current-limit threshold and lasts for five switching cycles, the protection is triggered, and the IC latches off.

Over-Temperature Protection

To prevent the IC from operating at exceedingly high temperatures, thermal shutdown is implemented by detecting the silicon die temperature. Once the die temperature exceeds the upper threshold (T_{ST}) and then drops below the lower threshold, the IC shuts down and resumes normal operation. Typically, the hysteresis is 20°C.

One-Time Programmable (OTP) Memory Mode

The MP3314A can change the register's default values one time using the one-time programmable (OTP) memory function. MPS factory can write the customized default register values with different suffix codes.

I²C Chip Address

The 7-bit most significant bit (MSB) device address is 0x28. After the start command, the I²C-compatible master sends a 7-bit address, followed by an eighth read (1) or write (0) bit (see Figure 4).

0	1	0	1	0	0	0	R/W

Figure 4: I²C Compatible Device Address

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I²C REGISTER MAP (7)

Add	Name	R/W	Default	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
02h	MODE_CTRL	R/W	9D	ADAPTIVE	PWMDR	ILIM		RESERVED			R_EN
03h	SBY_CHEN	R/W	7F	RESERVED	SBY_PWM	CHEN					
04h	FUNC_SET_0	R/W	70	RESERVED		OVP		RESERVED			
06h	ILED_SET_0	R/W	FF	ILED7:0							
07h	ILED_SET_1	R/W	3F	RESERVED	IMAX			ILED11:8			
08h	FUNC_SET_1	R/W	A7	RESERVED		UVLO_EN	RESERVED	ISET_EN		RESERVED	
0Ah	SLEW_FREQ	R/W	A0	SRSW		FSW		RESERVED			
0Bh	FSS_LEDS	R/W	66	RESERVED	FSPMF		FSPR	LEDS		TCOMP	RESERVED
0Eh	VOUT_SET	R/W	32	VO							
1Dh	ID	R	11	ID							
1Fh	FAULT	R	00	NC	FT_UVLO	FT_LEDG	FT_OTP	FT_OCP	FT_OVP	FT_LEDO	FT_LEDS

Note:

7) All registers can be written to the customized default values one time.

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I²C REGISTER DESCRIPTION

MODE_CTRL (02h)

The MODE_CTRL command sets loop control mode, dimming mode, and the current limit of the boost circuit. It can also enable or disable the IC.

Bits	Access	Bit Name	Default	Description
7	R/W	ADAPTIVE	1’b1	Sets boost loop control mode. 1’b1: Adaptive control mode (invalid) 1’b0: Manual control mode (VR application; requires OTP)
6	R/W	PWMDR	1’b0	Sets direct pulse-width modulation (PWM) dimming. 1’b0: Reserved 1’b1: Direct PWM dimming, where the LED current (I_{LED}) follows the external PWM signal (VR application; requires OTP)
5:3	R/W	ILIM	3’b011	Sets the cycle-by-cycle current limit. 3’b000: 0.45A 3’b001: 0.6A 3’b010: 0.75A 3’b011: 0.9A 3’b100: 1.05A 3’b101: 1.2A 3’b110: 1.35A 3’b111: 1.5A
2:1	R	RESERVED	N/A	Reserved.
0	R/W	R_EN	1’b1	Enables or disables the IC. This is the highest priority enable bit. When R_EN = 0, all blocks are disabled except for the I²C. 1’b0: Disabled 1’b1: Enabled If an external PWM signal is used for brightness control, it can also be used to enable/disable the IC. SBY_PWM (03h, bit[6]) can configure this function.

SBY_CHEN (03h)

The SBY_CHEN command can enable or disable standby mode as well as 6 LED current sources.

Bits	Access	Bit Name	Default	Description
7	R	RESERVED	N/A	Reserved.
6	R/W	SBY_PWM	1’b1	Enables standby mode when the PWM1 pin is pulled low for a minimum of 58ms. 1’b0: Disabled 1’b1: Enabled
5:0	R/W	CHEN	6’b111111	Enables the LED current source. These bits correspond to LED channel 1 to channel 6. CHENx = 1’b1: LED channel (x + 1) is enabled. CHENx = 1’b0: LED channel (x + 1) is disabled. PWM1 controls channel 1 to channel 3. PWM2 controls channel 4 to channel 6.

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FUNC_SET_0 (04h)

The FUNC_SET_0 command sets the brightness control source, over-voltage protection (OVP) threshold, and digital dithering function of the circuit.

Bits	Access	Bit Name	Default	Description
7:6	R	RESERVED	N/A	Reserved.
5:3	R/W	OVP	3’b110	Sets the output voltage (V_{OUT}) OVP threshold. 3’b010 = 21V 3’b011 = 25V 3’b100 = 30V 3’b101 = 34.5V 3’b110 = 39V 3’b111 = 43V
2:0	R	RESERVED	N/A	Reserved.

ILED_SET_0 (06h)

The ILED_SET_0 command sets the 8 least significant bits (LSB) of the 12-bit I_{LED} amplitude register.

Bits	Access	Bit Name	Default	Description
7:0	R/W	ILED7:0	8’hFF	Sets I_{LED} for the 8LSB. The 12-bit I_{LED} amplitude register further scales the maximum I_{LED} set by IMAX (07h, bits[6:4]).

ILED_SET_1 (07h)

The ILED_SET_1 command sets the maximum I_{LED} and the 4 most significant bits (MSB) of the 12-bit I_{LED} amplitude register.

Bits	Access	Bit Name	Default	Description
7	R	RESERVED	N/A	Reserved.
6:4	R/W	IMAX	3’b011	Configures the maximum I_{LED}. 3’b000: 5mA 3’b001: 10mA 3’b010: 15mA 3’b011: 20mA 3’b100: 23mA 3’b101: 25mA 3’b110: 30mA 3’b111: 50mA
3:0	R/W	ILED11:8	4’b1111	Sets I_{LED} for the 4MSB. The 12-bit I_{LED} amplitude register further scales the maximum I_{LED} set by IMAX, bits[6:4] of this command.

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FUNC_SET_1 (08h)

The FUNC_SET_1 command sets the transfer point of mixed dimming, under-voltage lockout (UVLO), and enable/disable control of the external setting resistor.

Bits	Access	Bit Name	Default	Description
7:6	R	RESERVED	N/A	Reserved.
5	R/W	UVLO_EN	1'b1	Enables V_{IN} UVLO. 1'b0: Disabled 1'b1: Enabled
4:3	R	RESERVED	N/A	Reserved.
2	R/W	ISET_EN	1'b1	Enables the external I_{LED} setting resistor. 1'b0: Disable 1'b1: Enable
1:0	R	RESERVED	N/A	Reserved.

SLEW_FREQ (0Ah)

The SLEW_FREQ command sets the boost switching slew rate, boost switching frequency (f_{SW}), and the I_{LED} dimming frequency in indirect PWM dimming mode and mixed dimming mode.

Bits	Access	Bit Name	Default	Description
7:6	R/W	SRSW	2'b10	Selects the switching slew rate. 2'b00: 1 driver 2'b01: 2 drivers 2'b10: 3 drivers 2'b11: Reserved
5:4	R/W	FSW	2'b10	Selects the boost f_{SW}. 2'b00: 312kHz 2'b01: 625kHz 2'b10: 1250kHz 2'b11: Reserved
3:0	R	RESERVED	N/A	Reserved.

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FSS_LEDS (0Bh)

The FSS_LEDS command sets the modulation frequency and the frequency spread range for the frequency spread spectrum (FSS) function. It can also set the protection threshold for LED short protection and the compensation saturation time for LEDx pin short to GND protection.

Bits	Access	Bit Name	Default	Description
7	R	RESERVED	N/A	Reserved.
6:5	R/W	FSPMF	2'b11	Selects the FSS modulation frequency. 2'b00: 1/100 of f_{SW} 2'b01: 1/150 of f_{SW} 2'b10: 1/200 of f_{SW} 2'b11: Disables the FSS function
4	R/W	FSPR	1'b0	Selects the FSS range. 1'b0: 1/10 of f_{SW} 1'b1: 1/16 of f_{SW}
3:2	R/W	LEDS	2'b01	Selects the LED short protection threshold. 2'b00: 2V 2'b01: 5V 2'b10: 7V 2'b11: 10V
1	R/W	TCOMP	1'b1	Selects the compensation saturated time for short LEDx to GND protection. 1'b0: 20ms 1'b1: 40ms
0	R	RESERVED	N/A	Reserved.

VOUT_SET (0Eh)

The VOUT_SET command sets V_{OUT} of the boost circuit. In adaptive mode, this command sets the initial V_{OUT} when the boost circuit starts up, and the final V_{OUT} is adjusted to a proper level adaptively. In manual mode, this command sets the final V_{OUT} for the LED strings.

Bits	Access	Bit Name	Default	Description
7:0	R/W	VO	8'h32	Sets V_{OUT}. 8'h00 = 16V, 8'h01 = 16.106V,…, 8'hFF = 43V. The step is 0.106V. Default = 21.25V.

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ID (1Dh)

The ID command indicates the device's ID.

Bits	Access	Bit Name	Default	Description
7:0	R	ID	8'h11	Sets the device's ID.

FAULT (1Fh)

The FAULT command indicates the status of each type of fault.

Bits	Access	Bit Name	Default	Description
7	R	RESERVED	N/A	Reserved.
6	R	FT_UVLO	1'b0	Indicates the UVLO fault indicator. 1'b0: There is no fault 1'b1: There is a fault If a fault occurs, the fault bit remains set to 1 until readback or the power becomes reset.
5	R	FT_LEDG	1'b0	Indicates the LEDx short to GND protection fault. 1'b0: There is no fault 1'b1: There is a fault If a fault occurs, the fault bit remains set to 1 until readback or the power becomes reset.
4	R	FT_OTP	1'b0	Indicates the over-temperature protection fault. 1'b0: There is no fault 1'b1: There is a fault If a fault occurs, the fault bit remains set to 1 until readback or the power becomes reset.
3	R	FT_OCP	1'b0	Indicates the over-current protection (OCP) fault. 1'b0: There is no fault 1'b1: There is a fault If a fault occurs, the fault bit remains set to 1 until readback or the power becomes reset.
2	R	FT_OVP	1'b0	Indicates the OVP fault indication. 1'b0: There is no fault 1'b1: There is a fault If a fault occurs, the fault bit remains set to 1 until readback or the power becomes reset.
1	R	FT_LEDO	1'b0	Indicates the LED open protection fault. 1'b0: There is no fault 1'b1: There is a fault If a fault occurs, the fault bit remains set to 1 until readback or the power becomes reset.
0	R	FT_LEDS	1'b0	Indicates the LED short protection fault. 1'b0: There is no fault 1'b1: There is a fault If a fault occurs, the fault bit remains set to 1 until readback or the power becomes reset.

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APPLICATION INFORMATION

Setting the Full-Scale LED Current

The full-scale LED current (I_{SET}) can be configured by the maximum LED current (I_{MAX}) (set via IMAX (07h, bits[6:4])) and the ISET resistor (R_{ISET}) when ISET_EN (08h, bit[2]) = 1b. I_{SET} can be calculated with Equation (1):

$$I_{ISET}\ (mA)=\frac{40}{R_{ISET}(k\Omega)}\ x\ I_{MAX} \quad (1)$$

For example, I_{MAX} = 20mA (IMAX = 011b) and R_{ISET} = 40kΩ, then I_{SET} is 20mA.

When ISET_EN = 0b, R_{ISET} is invalid, and I_{SET} is only configured via IMAX (07h, bits[6:4]).

Selecting the Input Capacitor

The input capacitor (C_{IN}) reduces the surge current drawn from the input supply and the switching noise from the device. The C_{IN} impedance at f_{SW} should be below the input source impedance to prevent the high-frequency switching current from passing through to the input. Use ceramic capacitors with X5R or X7R dielectrics for their low-ESR and small temperature coefficients. For most applications, a 10μF ceramic capacitor is sufficient.

Selecting the Inductor

The MP3314A requires an inductor to supply a higher V_{OUT} while being driven by V_{IN}. A larger-value inductor results in reduced ripple current and peak inductor current, as well as reduced stress on the internal N-channel MOSFET. However, the larger-value inductor also has a larger physical size, higher series resistance, and lower saturation current.

Choose an inductor that does not saturate under the worst-case load conditions. Select the inductance to ensure that the boost converter works in discontinuous conduction mode (DCM) to avoid subharmonic oscillations.

The required inductance can be calculated with Equation (2):

$$L \le \frac{V_{IN_MIN} \times (V_{OUT} - V_{IN_MIN})}{V_{OUT} \times f_{SW} \times I_{CL}} \quad (2)$$

Where V_{IN_MIN} and V_{OUT} are the minimum input voltage and output voltages, f_{SW} is the switching frequency, and I_{CL} is the cycle-by-cycle current limit.

With the given inductance, the inductor DC current rating exceeds the maximum input peak inductor current by a minimum of 40% for most applications. The inductor's DC resistance must be minimized to achieve higher efficiency.

Selecting the Output Capacitor

The output capacitor (C_{OUT}) keeps the V_{OUT} ripple small and ensures feedback loop stability. The C_{OUT} impedance must be low at f_{SW}. Ceramic capacitors with X7R dielectrics are recommended for their low-ESR characteristics. For VR applications, a large electrolytic C_{OUT} is required to maintain V_{OUT} and the output power. The required electrolytic capacitance can be calculated with Equation (3):

$$\begin{cases} C \ge \dfrac{2 \times D_{PWM_MAX} \times (V_{OUT} \times I_{OUT} - V_{IN_MIN} \times I_{IN})}{f_{PWM_MIN} \times \left[V_{OUT}^2 - (V_{OUT} - \Delta V)^2 \right]} \\ C \le \dfrac{2 \times (1 - D_{PWM_MAX}) \times V_{IN_MIN} \times I_{IN}}{f_{PWM_MIN} \times \left[V_{OUT}^2 - (V_{OUT} - \Delta V)^2 \right]} \end{cases} \quad (3)$$

$$I_{IN} = \frac{I_{CL}^{\ 2} \times L \times f_{SW} \times V_{OUT}}{2 \times V_{IN_MIN} \times (V_{OUT} - V_{IN_MIN})}$$

Where D_{PWM_MAX} and f_{PWM_MIN} are the maximum duty and the minimum frequency of the PWM1 and PWM2 input signals in application, I_{OUT} is the total LED current when PWM1 and PWM2 are both on, I_{IN} is the input current, ΔV is the maximum voltage drop of the electrolytic capacitor when PWM1 and PWM2 are both on.

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PCB Layout Guidelines

Efficient PCB layout and placement of the high-frequency switching path is critical to prevent noise and electromagnetic interference. Refer to Figure 5 and follow the guidelines below:

1. All logic signals must be referred to AGND.
2. Externally connect PGND to AGND.
3. Route PGND away from the logic signals.
4. Keep the loop between the SW and PGND pins, output diode (D1), and output capacitor (C1 and C2) as short as possible due to the high-frequency pulse current.

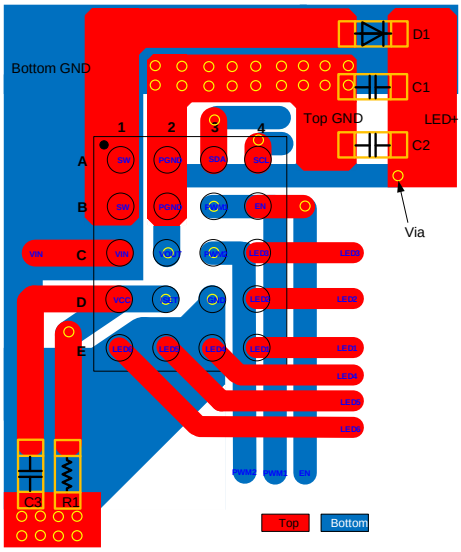

Figure 5: Recommended PCB Layout

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TYPICAL APPLICATION CIRCUIT

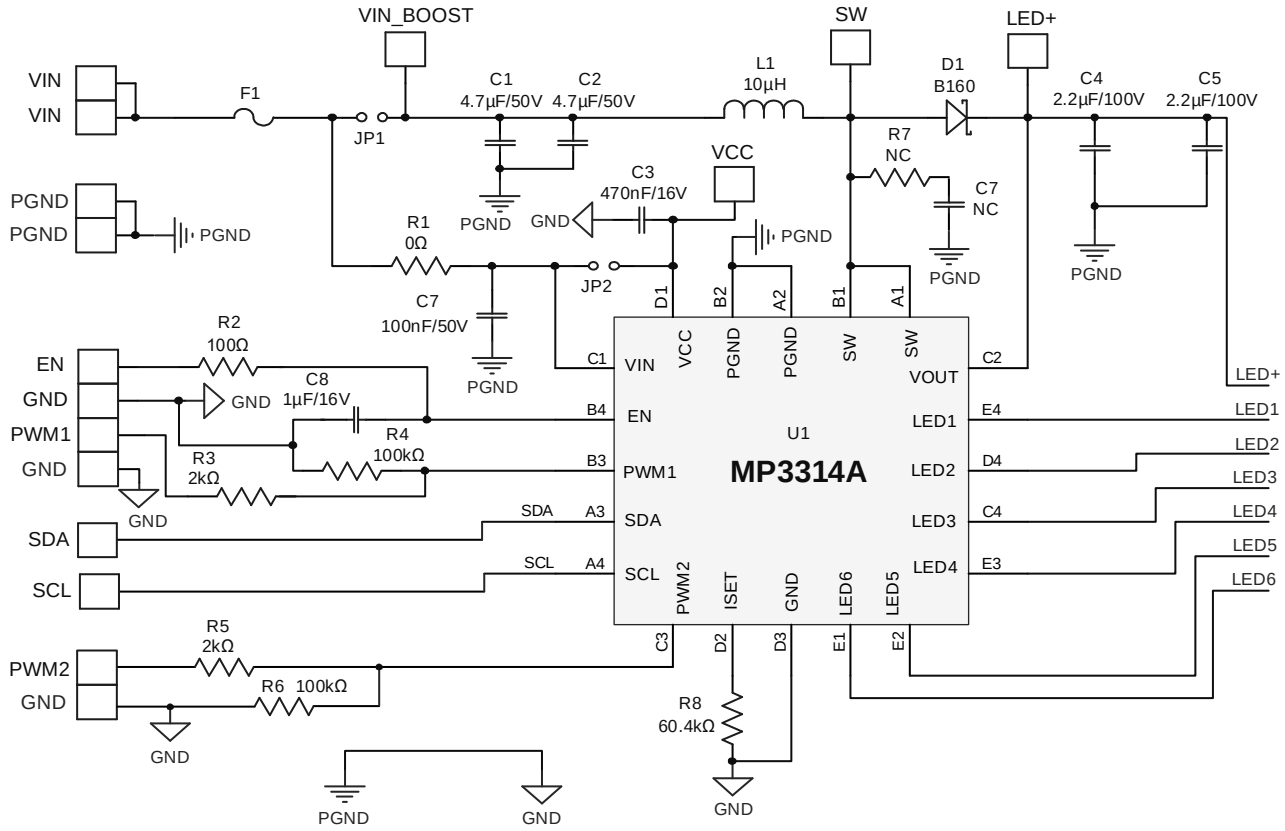

Figure 6: Typical Application Circuit

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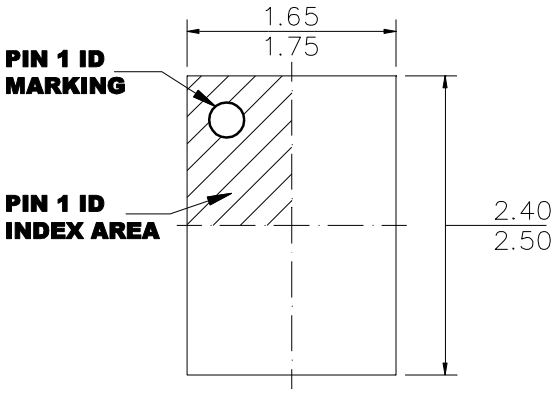
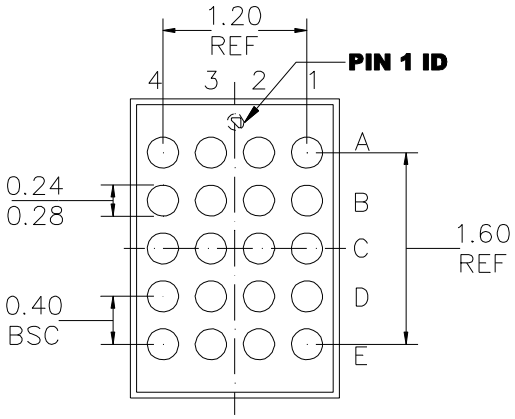
PACKAGE INFORMATION

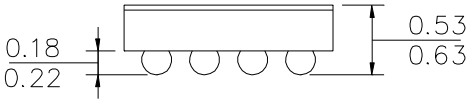
WLCSP-20 (1.7mmx2.45mm)



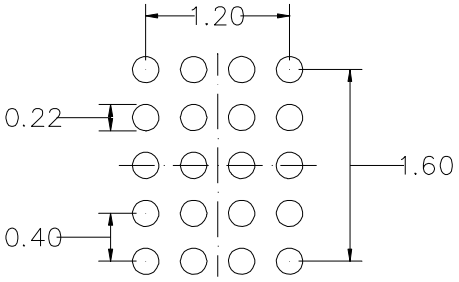
TOP VIEW



BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) BALL COPLANARITY SHALL BE 0.05 MILLIMETER MAX.
3) JEDEC REFERENCE IS MO-211.
4) DRAWING IS NOT TO SCALE.

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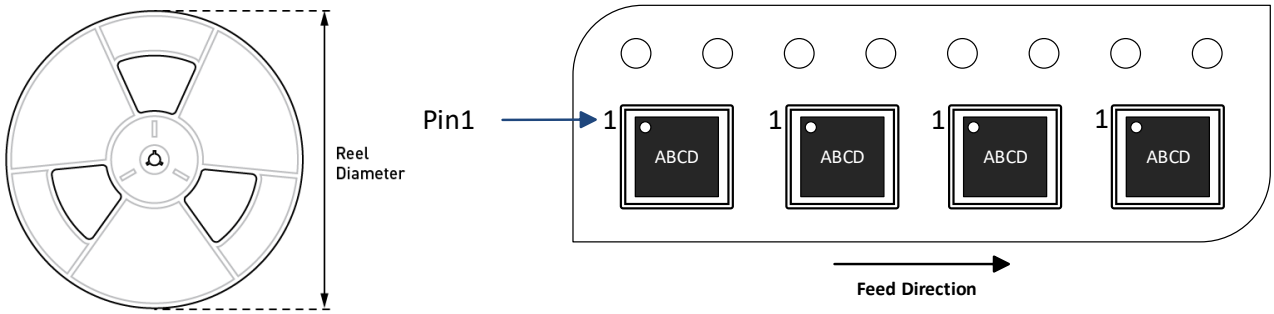
CARRIER INFORMATION



Part Number	Package Description	Quantity/ Reel	Quantity/ Tube	Quantity/ Tray	Reel Diameter	Carrier Tape Width	Carrier Tape Pitch
MP3314AGC-Z	WLCSP-20 (1.7mmx 2.45mm)	3000	N/A	N/A	7in	8mm	4mm

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REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	9/26/2024	Initial Release	-

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